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*MARS.**

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"It can hardly be urged that the general interest which has been expressed in regard to the opposition of *Mars* this year is merely due to the exigencies of the dull season. The newspapers, crowded as they are with their staple political matters, can still make room for paragraphs, columns, and even for long articles on the phenomena of our neighboring globe. It is worth while to examine the circumstances which have led to the direction of so much attention to this particular heavenly body at this particular time.

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From one cause or another, it happens that *Mars* is the most world-like of all the other globes which come within the range of effective observation. It would, indeed, be very rash to assert that other bodies may not have a closer resemblance to our earth than *Mars* has, but of them we have either little knowledge, as in the case of *Venus*, or no knowledge at all. No doubt both *Jupiter* and *Saturn* can vie with *Mars* in the copiousness of detail with which they delight the astronomers who study them. These grand planets are deserving of every attention, but then the interest they excite is of a wholly different kind from that which makes a view of *Mars* so attractive. *Jupiter* offers us a meteorological study of the most astounding cloud-system in creation. *Saturn* gives an illustration of a marvelous dynamical system the like of which would never have been thought possible had it not

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actually presented itself to our notice. But the significance of *Mars* is essentially derived from those points of resemblance to the earth which are now engrossing attention. *Mars* is clearly a possible world, presenting both remarkable analogies and remarkable contrasts to our own world, and inducing us to put forth our utmost endeavors to utilize so exceptional an occasion as that presented in the close approach which it has now made. Let us see what we have learned about this globe.

In the first place, it should be noticed that *Mars* must be a small world in comparison with our own. The width of this globe is only 4200 miles, so that its volume is but the seventh part of that of the earth. The weight of *Mars* is even less than what might have been expected from his bulk. It would take nearly ten globes, each as heavy as *Mars*, to form a weight equal to that of the earth. This fundamental difference in dimensions between *Mars* and our globe is intimately connected with certain points of contrast which it offers to the earth. Of these the most important is that which concerns the atmosphere. When we consider the qualification of a globe as a possible abode for organic beings, it is natural to inquire first into the presence or the absence of an atmosphere. Seeing that our earth is enveloped by so copious a shell of air, it follows that the beings which dwell upon its surface must be specially adapted to the conditions which the atmosphere imposes. Most, if not all, animals utilize this circumstance by obtaining a proximate source of energy in the union of oxygen from the atmosphere with oxidizable materials within their bodies. In this respect the atmosphere is of such fundamental importance that it is difficult for us to imagine what that type of life must be which would be fitted for the inhabitants of an airless globe. In other respects, which are hardly less important, the conditions of life are also dependent on the fact that we live at the bottom of an ocean of air. It is the atmosphere which, to a large extent, mitigates the fierceness with which the sun's rays would beat down on the globe if it were devoid of such protection. Again, at night, the atmospheric covering serves to screen us from the cold that would otherwise be the consequence of unrestricted radiation from the earth to space. It is, therefore, obvious that the absence of a copious atmosphere, though perhaps not absolutely incompatible with life of some kind, must still necessitate types of life of a wholly different character from those with which we are familiar. In attempting, therefore, to form an

estimate of the probability of life on another world, it is of essential importance to consider whether it possesses an atmosphere.

We may here lay down a canon which appears to be pretty general among the celestial bodies which are accessible to our observations. It may be thus stated. The larger the body the more copious the atmosphere by which that body is surrounded. Of course this rule has to be understood with certain qualifications, and perhaps some exceptions to it might be suggested, but as a broad general fact it will hardly be questioned. Thus, to take at once the largest body of our system and one of the smallest — the sun and moon — they both provide striking exemplifications of the principle in question. It is well known that the sun is enveloped by an atmosphere alike remarkable for the prodigious extent that it occupies and for the copiousness of the gases and vapors that abound in it. On the other hand, the moon, which is by far the smallest of the bodies readily accessible to our observations, is, if not entirely devoid of gaseous investment, at all events only provided with the scantiest covering of this nature. But the chief interest that the principle we have laid down possesses, is found in the explanation which has been given of it. That explanation is both so recent and so remarkable that I am glad here to have the opportunity of setting it forth, as it has an important application to *Mars*. The view of the subject here given is due to Dr. G. JOHNSTONE STONEY, F. R. S., who recently communicated it to the Royal Dublin Society.

Modern research has demonstrated that what we call a gas is in truth a mighty host of molecules far too small to be perceptible by the most powerful microscope. Each of these molecules is animated by a rapid movement, which is only pursued for a short distance in one direction before a rencontre takes place with some other molecule, in consequence of which the directions and velocities of the individual molecules are continually changing. For each gas the molecules have, however, a certain average pace, which is appropriate to that gas for that temperature, and when two or more gases are blended, as in our atmosphere, then each molecule of the constituent gases continues to move with its own particular speed. Thus, in the case of the air, the molecules of oxygen, as well as the molecules of nitrogen, are each animated by their characteristic velocity, and the same may be said of the molecules of carbonic acid or of any other gas which in more or less abundance may happen to be diffused through our air. For

two of the chief gases the average velocities of the molecules are as follows: oxygen, a quarter of a mile per second; hydrogen, one mile per second; in each case the temperature is taken to be 64° C. below zero, being presumably that at the confines of the atmosphere. It will be noticed that there is a remarkable difference between the speeds of the two molecules here mentioned. That of hydrogen is by far the greatest of any gas.

We may now recall a fundamental fact in connection with any celestial body, large or small. It is well known that, with the most powerful pieces of artillery that can be forged, a projectile can be launched with a speed of about half a mile per second. If the cannon were pointed vertically upwards the projectile would soar to a great elevation, but its speed would gradually abate, and the summit of its journey would be duly reached, after which it would fall back again on the earth. Such would undoubtedly be the case if the experiment were made on a globe resembling our own in size and mass. But on a globe much smaller than the earth, not larger, for instance, than are some of the minor planets, it is certain that a projectile shot aloft from a great Armstrong gun would go up and up, and would never return. The lessening gravitation of the body would fail to recall it. Of course we are here reminded of JULES VERNE'S famous Columbiad. According to that philosopher, if a cannon were pointed vertically and the projectile were discharged with a speed of seven miles a second, it would soar aloft, and whether it went to the moon or not, it would at all events not return to the earth except by such a marvelous series of coincidences as those which he has described. But the story will, at all events, serve to illustrate the fact that for each particular globe there is a certain speed with which if a body leaves the globe it will not return.

It is a singular fact that hydrogen in its free state is absent from our atmosphere. Doubtless many explanations of a chemical nature might be offered, but the argument Dr. STONEY has brought forward is most interesting, inasmuch as it shows that the continued existence of hydrogen in our atmosphere would seem to be impossible. No doubt the average speed at which the molecules of this gas are hurrying about is only one mile a second, and therefore only a seventh of the critical velocity required to project a missile from the earth so as not to return. But the molecules are continually changing their velocity, and may sometimes attain a speed which is seven times as great as the average.

Suppose, therefore, that a certain quantity of hydrogen were diffused through our air, every now and then a molecule of hydrogen in its wandering would attain the upper limit of our atmosphere, and then it would occasionally happen that with its proper speed it would cross out into space beyond the region by which its movements would be interfered with by the collisions between other atmospheric molecules. If the attraction of the earth was sufficient to recall it, then, of course, it would duly fall back, and in the case of the more sluggishly moving atmospheric gases the velocity seems always small enough to permit the recall to be made. But it happens in the case of hydrogen that the velocity with which its molecules are occasionally animated rises beyond the speed which could be controlled by terrestrial gravity. The consequence is that every now and then a molecule of hydrogen would succeed in bolting away from the earth altogether, and escaping into open space. Thus it appears that every molecule of free hydrogen which happened to be present in an atmosphere like ours would have an unstable connection with the earth, for wherever in the vicissitudes of things it happened to reach the very uppermost strata it would be liable to escape altogether. In the course of uncounted ages it would thus come to pass that the particles of hydrogen would all effect their departure, and thus the fact that there is at present no free hydrogen in the air over our heads may be accounted for.

If the mass of the earth were very much larger than it is, then the velocities with which the molecules of hydrogen wend their way would never be sufficiently high to enable them to quit the earth altogether, and consequently we might in such a case expect to find our atmosphere largely charged with hydrogen. Considering the vast abundance of hydrogen in the universe, it seems highly probable that its absence from our air is simply due to the circumstances we have mentioned. In the case of a globe so mighty as the sun, the attraction which it exercises, even at the uppermost layers of its atmosphere, is so intense that the molecules of hydrogen never attain pace enough to enable them to escape. Their velocity would have to be much greater than it ever can be if they could dart away from the sun as they have done from the earth. It is not, therefore, surprising to find hydrogen in the solar atmosphere. In a similar manner we can explain the abundance with which the atmosphere of other massive suns like *Sirius* or *Vega* seem to be charged with hydrogen.

The attraction of these vast globes is sufficiently potent to retain even an atmosphere of this subtle element.

It is now easy to account for the absence of atmosphere from the moon. We may feel confident from the line of reasoning here followed that neither of the gases, oxygen or nitrogen, to say nothing of hydrogen, could possibly exist in the free state on a globe of the mass and dimensions of our satellite. The pace with which the molecules of oxygen and nitrogen speed on their way would be quite sufficient to render their abode unstable if it should ever have appeared that circumstances placed such gases on the moon. We need, therefore, feel no surprise at the absence of any atmosphere from the neighboring globe. The explanation is given by the law of dynamics. We are placed at too great a distance from the small planets or asteroids, as they are called, to be able to see whether or not they have any gaseous surroundings. But it is possible, from the ingenious argument of Dr. STONEY, to assure ourselves that such small bodies must be quite as devoid of air as the moon. There are, we know, globes in our system only a few miles in diameter, and so small in mass that a cricket ball there, receiving the velocity it would get from the bat of a GRACE, would go off into space, never to return. It is quite obvious that the molecules of any gases we know would be far too nimble in their movements to remain prisoners at the surface of little globes of this description, to which their only bond was the feeble attraction of gravitation. It is, therefore, in the highest degree improbable — we might, indeed, almost say impossible — for gaseous surroundings to be preserved by any globe where the mass is not considerably greater than that of the moon.

In applying these considerations to *Mars* we have first to note that its mass and size are intermediate between those of the earth and the moon. It is much more capable of retaining an atmosphere than the moon, though its capability in this respect falls short of that possessed by the earth. But in such a case it is essential to depend not on mere generalities, but on the actual numerical facts of the case. Without going too deeply into details, it is sufficient to observe that there must be for each globe a certain critical velocity represented by the least pace at which a missile projected from it will succeed in escaping altogether. In discussing this we may leave out of view the question of the resistance which the air opposes to the passage of the projectile.

This is, no doubt, of vital importance in cases where actual artillery practice is concerned, yet it is not material to our present inquiry. The problem which we are considering depends on the movements of the molecules of air at the summit of the atmosphere, and the question is simply whether after they have made an incursion into free space there is sufficient efficiency in the attraction of the globe to effect their recall.

At the surface of *Mars* the speed which would carry a body away from its surface altogether is about three miles per second. It seems certain that the velocity of the molecules of hydrogen is often far in excess of this, and consequently free hydrogen is impossible as a permanent ingredient of the *Martian* atmosphere. Oxygen, however, has a molecular velocity only about one-fourth of that of hydrogen, and it seems unlikely that the oxygen molecules can ever have sufficient velocity to permit their escape from an atmosphere surrounding *Mars*. There is nothing, therefore, to prevent this element from being now present.

But the case of the vapor of water is especially instructive and interesting. Its molecules have a speed which averages about one-third of that attained by the molecules of hydrogen. It would seem that the utmost pace that the molecules of water could attain (being perhaps seven times the average velocity) would be about 2⅓ miles per second. Now, this would not be enough for escape from *Mars*, for we have seen that a speed of three miles per second would be required for this purpose. This argument suggests that the globe of *Mars* happens to approach very closely the dimensions and mass of the smallest world on which the continued existence of water was possible. It would, perhaps, be going rather too far to say that a world almost the size of *Mars* must therefore be the smallest on which life could possibly be supported, but it is plain that our argument tends to support such a proposition.

The discussion we have just given will prepare us to believe that a planet with the size and mass of *Mars* may be expected to be encompassed with an atmosphere. Our telescopic observations completely bear this out. It is perfectly certain that there is a certain shell of gaseous material investing *Mars*. This is shown in various ways. We note the gradual obscuration of objects on the planet as they approach the edge of the disk, where they are necessarily viewed through a greatly increased thickness of *Martian* atmosphere. We also observe the clearness

with which objects are exhibited at the centre of the disk of *Mars*, and though this may be in some measure due to the absence of distortion from the effects of foreshortening, it undoubtedly arises to some extent from the fact that objects in this position are viewed through a comparatively small thickness of the atmosphere enveloping the planet. Clouds are also sometimes seen apparently floating in the upper region of *Mars*. This, of course, is possible only on the supposition that there must be an atmosphere which formed the vehicle by which clouds were borne along. It is, however, quite obvious that the extent of the *Martian* atmosphere must be quite insignificant when compared with that by which our earth is enveloped. It is a rare circumstance for any of the main topographical features, such as the outlines of its so-called continents or the coasts of its so-called seas, to be obscured by clouds to an extent which is appreciable except by very refined observations. Quite otherwise would be the appearance which our globe would present to any observer who would view it say from *Mars*, or from some other external world at the same distance. The greater part of our globe would seem swathed with vast clouds, through which only occasional peeps could be had at the actual configuration of its surface. I dare say a Martian astronomer who had an observatory with sufficiently good optical appliances, and who possessed sufficient patience, might, in the course of time, by availing himself of every opportunity, gradually limn out a chart of the earth which would in some degree represent that with which we are familiar in our atlases. It would, however, be a very tedious matter, owing to the interruptions to the survey, caused by the obscurities in our atmosphere. The distant astronomer would never be able to comprehend the whole of our earth's features in a bird's-eye glance as we are able to do with those features on that hemisphere of *Mars* which happens to be turned toward us on a clear night.

As to what the composition of the atmosphere on *Mars* may be we can say but little. In so far as the sustenance of life is concerned, the main question of course turns on the presence or the absence of oxygen. It may be pertinent to this inquiry to remark here that a globe surrounded by air may at one epoch of its career have free oxygen as an ingredient in its atmosphere, while at other epochs free oxygen may be absent. This may arise from another cause besides the possible loss of the gas by diffusion into space from small globes in the manner already ex-

plained. Indeed, it seems quite probable that the oxygen in our own air is not destined forever to remain there. It passes through various vicissitudes by being absorbed by animals and then restored again in a free state under the influence of vegetation. But there is an appetite for oxygen among the inorganic materials of our globe which seems capable of using up all the oxygen on the globe and still remain unsatiated. We have excellent grounds for believing that there is in the interior of the earth a quantity of metallic iron quite sufficient to unite with all the free oxygen of the air so as to form iron oxide. In view of the eagerness with which oxygen and iron unite, and the permanence of the compound which they form, it is impossible for us to regard the presence of oxygen in the air as representing a stable condition of things. It follows that, even though there may be no free oxygen in the atmosphere of *Mars*, it is by no means certain that this element has always been absent. It is, however, not at all beyond the reach of scientific resources to determine what the actual composition and extent of the atmosphere of *Mars* may be, though it can hardly be said that as yet we are in full possession of the truth.

An almost equally important question is as to the telescopic evidence of the presence of water on *Mars*. Here, again, we have to be reminded of the fact that even at present, when the planet is relatively so near us, it is still actually a very long way off. It would be impossible for us to say with certainty that an extent which by its color and general appearance looked like an ocean of water was really water, or was even a fluid at all. It is so easy to exaggerate the capabilities of our great telescope that it may be well to recount what is the very utmost that could be expected from even our greatest instrument when applied to the study of *Mars*. Let us consider, for example, the capabilities of the LICK telescope in aiding such an inquiry as that before us. This instrument, both from its position and its optical excellence, offers a better view of *Mars* at the present time than can be obtained elsewhere. But the utmost that this telescope could perform in the way of rendering remote objects visible is to reduce the apparent distance of the object to about one-thousandth part of its actual amount. Some, indeed, might consider that even the LICK instrument would not be capable of giving so great an accession to our powers as this statement expresses. However, I am willing to leave the figure at this amount, only remembering

that if I estimated the powers of the telescope less highly than these facts convey, the arguments on which I am entering would be correspondingly strengthened.

As we have already said, *Mars* is at present at a distance of 35,000,000 miles, and if we look at it through a telescope of such a power as we have described, the apparent distance is reduced to one-thousandth part. In other words, all that the best telescope can possibly do is to exhibit the planet to us as it would be seen by the unaided eye if it were brought into a distance of 35,000 miles. This will demonstrate that even our greatest telescopes cannot be expected to enable us to answer the questions that are so often asked about our neighboring globe. What could we learn of Europe if we had only a bird's-eye view of it from a height of 35,000 miles, that is to say, from a height which was a dozen times as far as from the shores of Europe to America? The broad outlines of the coast might, of course, be seen by the contrast of the color of a continent and the color of the ocean. Possibly a great mountain mass like the Alps would be sufficiently noticeable to permit some conjecture as to its character to be formed. But it is obvious that it would be hopeless to expect to see details. The smallest object that would be discernable on *Mars* must be as large as London. It would not be possible to see a point so small as would either Liverpool or Manchester be if they were on that planet. There is, no doubt, a remarkable contrast between the dark colors of certain parts of *Mars* and the ruddy colors of other parts. It would, however, be going rather far to assert that the former must be oceans of water and the latter continents of land. This may indeed be the case, and most astronomers, I believe, think that it is the case, but it certainly has not yet been proved to be so.

Undoubtedly the most striking piece of evidence that can be adduced in favor of the supposition that there is water on *Mars* is derived from the "snowy" poles on the planet. The appearance of the poles of *Mars* with their white caps is one of the most curious features of the solar system. The resemblance to the structure of our own polar regions is extremely instructive. It is evident that there must be some white material which from time to time gathers in mighty volume round the north and south poles of the planet.

It is also to be noticed that this accumulation is not permanent. The amount of it waxes and wanes in correspondence with

the variations of the seasons on *Mars*. It increases during *Mars's* winter, and it declines again during *Mars's* summer. In this respect the white regions, whatever they may be composed of, present a noteworthy contrast to the majority of the other features on the planet. The latter offer no periodic changes to our notice; they are evidently comparatively permanent marks, not to any appreciable extent subject to seasonal variations. When we reflect that this white material is something which grows and then disappears according to a regular period, it is impossible to resist the supposition that it must be snow, or possibly the congealed form of some liquid other than water, which during *Mars's* summer is restored to a fluid state. There can hardly be a doubt that if we were ever able to take a bird's-eye view of our own earth its poles would exhibit white masses like those which are exhibited by *Mars*, and the periodic fluctuations at different seasons would produce changes just like those which are actually seen on *Mars*. It seems only reasonable to infer that we have in *Mars* a repetition of the terrestrial phenomenon of arctic regions on a somewhat reduced scale.

Among the features presented by *Mars* there are others in addition to the polar caps, which seem to suggest the existence of water. It was in September, 1877, when *Mars* was placed in the same advantageous position for observation that it occupies at present, that a remarkable discovery was made by Professor SCHIAPARELLI, the director of the Milan observatory. In the clear atmosphere and the convenient latitude of the locality of his observatory, he was so fortunate as to observe marks not readily discernible under the less advantageous conditions in which our observatories are placed. Up to his time it was no doubt well known that the surface of *Mars* could be mapped out into districts marked with more or less distinctness, so much so that charts of the planet had been carefully drawn and names had been assigned to the various regions which could be indicated with sufficient certainty. But at the memorable opposition to which we have referred, the distinguished Italian astronomer discovered that the tracts generally described as "continents" on *Mars* were traversed by long, dark "canals," as he called them. They must have been each at least sixty miles wide, and in some cases they were thousands of miles in length. Notwithstanding the dimensions to which these figures correspond, the detection of the *Martian* canals indicates one of the utmost refinements of astro-

nomical observation. The fact that they are so difficult to see may be taken as an illustration of what I have already said as to the hopelessness of discerning any object on this planet unless it be of colossal dimensions.

It is impossible to doubt that considerable changes must be in progress on the surface of *Mars*. It is true that, viewed from the distance at which we are placed, the extent of the changes, though intrinsically vast, seem relatively insignificant. There is, however, too much testimony as to the changes to allow of hesitation.

Speculations have naturally been made as to the explanation of these wonderful canals. It has been suggested that they may indeed be rivers; but it hardly seems likely that the drainage o continents on so small a globe as *Mars* would require an elaborate system of rivers each sixty miles wide and thousands of miles in length. There is, however, a more fatal objection to the river theory, in the fact that the marks we are trying to interpret sometimes cross a *Martian* continent from ocean to ocean, while on other occasions they seem to intersect each other. Such phenomena are, of course, well-nigh impossible if these so-called canals were in any respect analogous to the rivers which we know on our own globe. It can, however, hardly be doubted that if we assume the dark regions to be oceans, the canals do really represent some extension of the waters of these oceans into the continental masses. Other facts which are known about the planet suggest that what seem to be vast inundations of its continents must occasionally take place. Nor is it surprising that such vicissitudes should occur on a globe circumstanced like *Mars*. Here, again, it is well to remember the small size of the planet, from which we may infer that it has progressed through its physical evolution at a rate more rapid than would be possible with a larger globe, like the earth. The sea is constantly wearing down the land, but by upheavals arising from the intensely heated condition of the interior of our globe, the land is still able to maintain itself above the water. It can, however, hardly be doubted that if our earth had so far cooled that the upheavals had either ceased or were greatly reduced, the water would greatly encroach on the land. On a small globe like *Mars* the cooling of the interior has so far advanced that, in all probability, the internal heat is no longer an effective agent for indirectly resisting the advance of the water, and, consequently, the observed submergence is quite to be expected.

That there may be types of life of some kind or other on *Mars* is, I should think, very likely. Two of the elements, carbon and hydrogen, which are most intimately associated with the phenomena of life here, appear to be among the most widely distributed elements throughout the universe, and their presence on *Mars* is in the highest degree probable. But what form the progress of evolution may have taken on such a globe as *Mars* it seems totally impossible to conjecture. It has been sometimes thought that the ruddy color of the planet may be due to vegetation of some peculiar hue, and there is certainly no impossibility in the conception that vast forests of some such trees as copper-beeches might impart to continental masses hues not unlike those which come from *Mars*. Speculations have also been made as to the possibility of there being intelligent inhabitants on this planet, and I do not see how any one can deny the possibility, at all events, of such a notion. I would suggest, however, that as our earth has only been tenanted by intelligent beings for an extremely brief part of its entire history, say, for example, for about one-thousandth part of the entire number of years during which our globe has had an independent existence, so we may fairly conjecture that the occupancy of any other world by intelligent beings might be only a very minute fraction in the span of the planet's history. It would, therefore, be highly improbable, to say the least of it, that in two worlds so profoundly different in many respects as are this earth and *Mars*, the periods of occupancy by intelligent beings should happen to be contemporaneous. I should therefore judge that, though there may once have been, or though there may yet be, intelligent life on *Mars*, the laws of probability would seem against the supposition that there is such life there at this moment.

We have also heard surmises as to the possibility of the communication of inter-planetary signals between the earth and *Mars*, but the suggestion is a preposterous one. Seeing that a canal sixty miles wide and a thousand miles long is an object only to be discerned on exceptional occasions, and under most favorable circumstances, what possibility would there be that, even if there were inhabitants on *Mars* who desired to signal to this earth, they could ever succeed in doing so? We are accustomed to see ships signaling by flags, but what would have to be the size of the flags by which the earth could signal to *Mars*, or *Mars* signal to the earth? To be effective for such purpose each of the flags

should be at least as big as Ireland. It is true, no doubt, that small planets would be fitted for the residence of large beings, and large planets would be proper for small beings. The Lilliputians might be sought for on a globe like *Jupiter*, and the Brobdingnagians on a globe like *Mars*, and not *vice versâ*, as might be hastily supposed. But no Brobdingnagian's arms would be mighty enough to wave the flag on *Mars* which we should be able to see here. No building that we could raise, even were it a hundred times more massive than the Great Pyramid, would be discernible by the *Martian* astronomer, even had he the keenest eyes and the most potent telescopes of which our experience has given us any conception.

THE SUN'S MOTION IN SPACE.—III.*

By W. H. S. Monck.

Some time ago I communicated to this Society a simple mode of estimating the sun's motion in space, which I believed to be sufficiently accurate until we possess more reliable data than at present. I lately applied this method to Professor Porter's Catalogue of 301 stars, with proper motion of half a second or upwards, which appeared in *The Astronomical Journal* for June 13, 1892. I found that on seeking to divide the stars in respect of R. A. into two equal parts, one of which should contain the maximum amount of increasing and the other of diminishing Right Ascensions, the best divisions were from 7^h to 19^h and from 19^h to 7^h, thus fixing the Right Ascension of the sun's goal at $285°$ (for the epoch 1900). The results were as follows:

	Stars with motions in Increasing R. A.	Stars with motions in Diminishing R. A.	Stars with No motion in R. A.
7^h to 19^h	37	103	3
19^h to 7^h	118	39	1

Dividing the stars with no motion in R. A. equally between + and —, and assuming that if the sun were motionless the proper motions in increasing and diminishing R. A. would be equal for both divisions, the result for 19^h to 7^h makes the sun's motion in R. A. exactly equal to the average motion of the stars, having

* See *Publications A. S. P.*, Vol. IV., page 70.